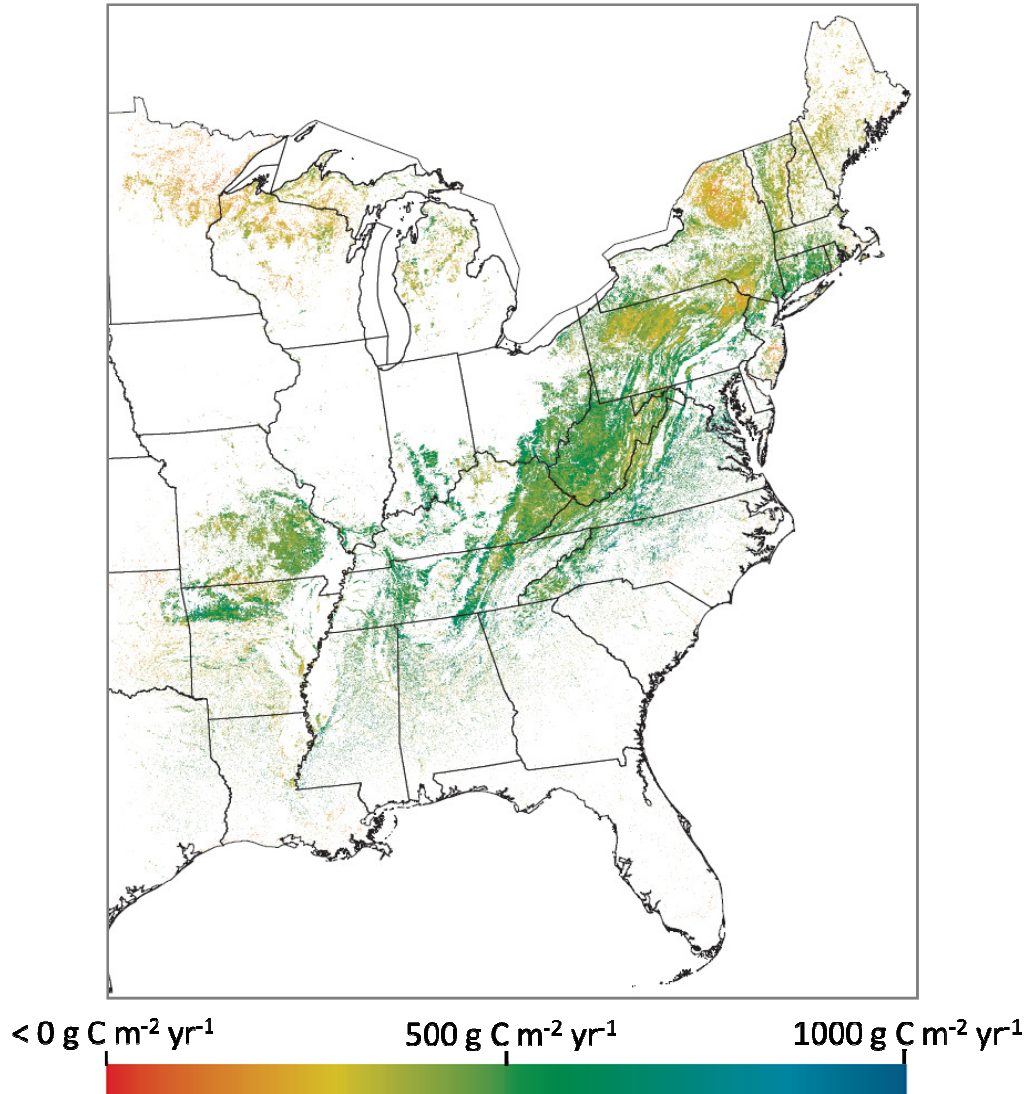
An aerial photograph showing a vast, dense forest with a thick canopy of green trees. The perspective is from directly above, looking down on the forest floor. The trees are closely packed, creating a textured, green surface. The lighting is bright, suggesting a sunny day, with some areas of the canopy appearing slightly more illuminated than others.

Chronic water stress reduces carbon storage in a Eastern deciduous forest

**Edward Brzostek, Danilo Dragoni, Hans
Peter Schmid, A. Faiz Rahman, Daniel
Sims, Craig A. Wayson, Daniel J.
Johnson and Richard P. Phillips**

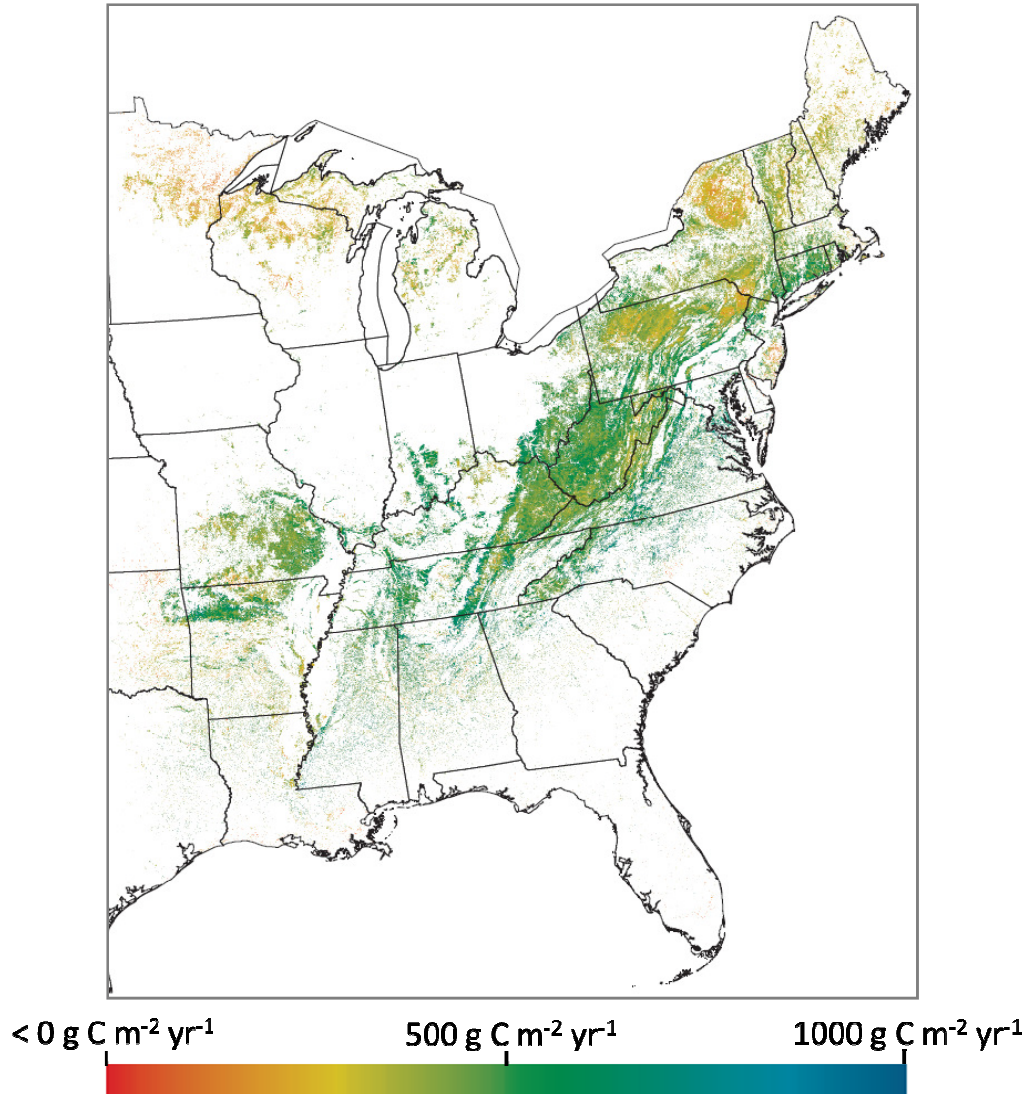
Eastern deciduous forests are an important global sink for atmospheric CO₂



From 2000-2006, these forests accounted for roughly 30% of the terrestrial land sink in the conterminous US (Xiao et al. 2011 Ag. For. Met.)

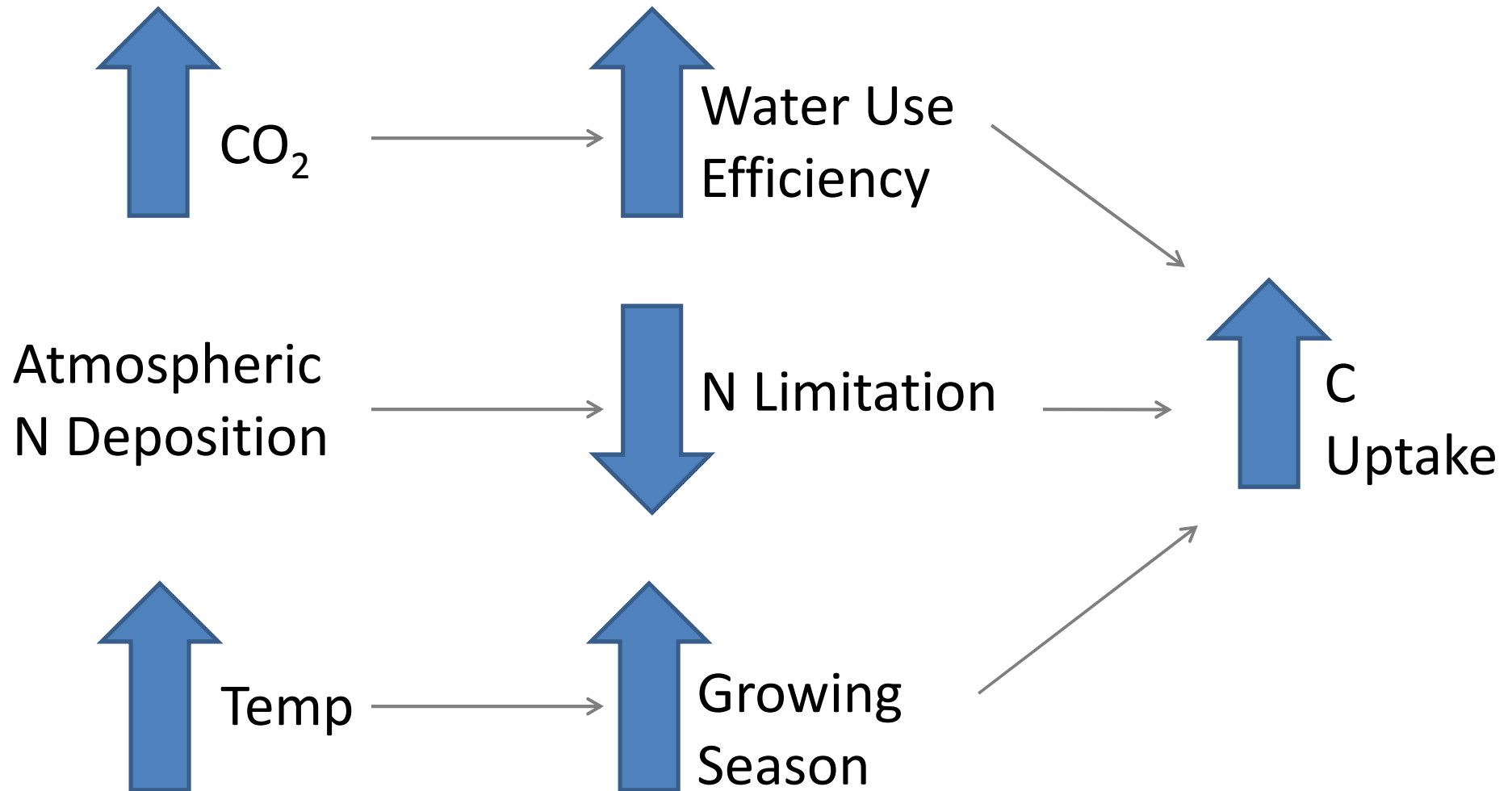
On the order of 0.24 Pg C m⁻² yr⁻¹

Eastern deciduous forests are an important global sink for atmospheric CO₂

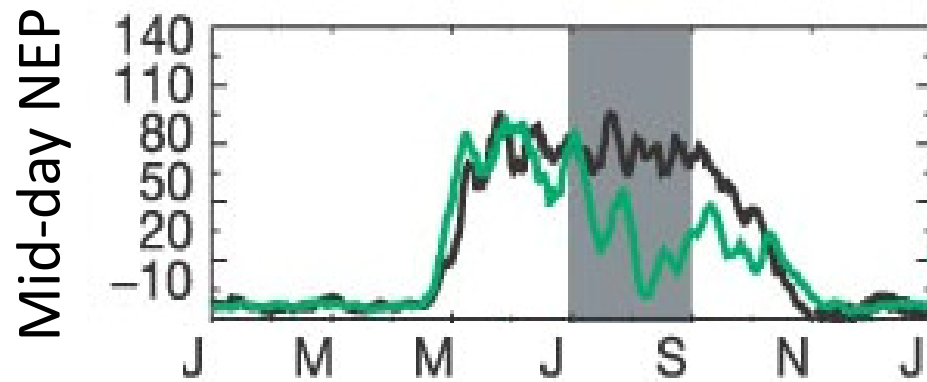


It remains uncertain whether the strength of this sink will persist in the future...

Potential Positive Feedbacks on C Uptake by Forests



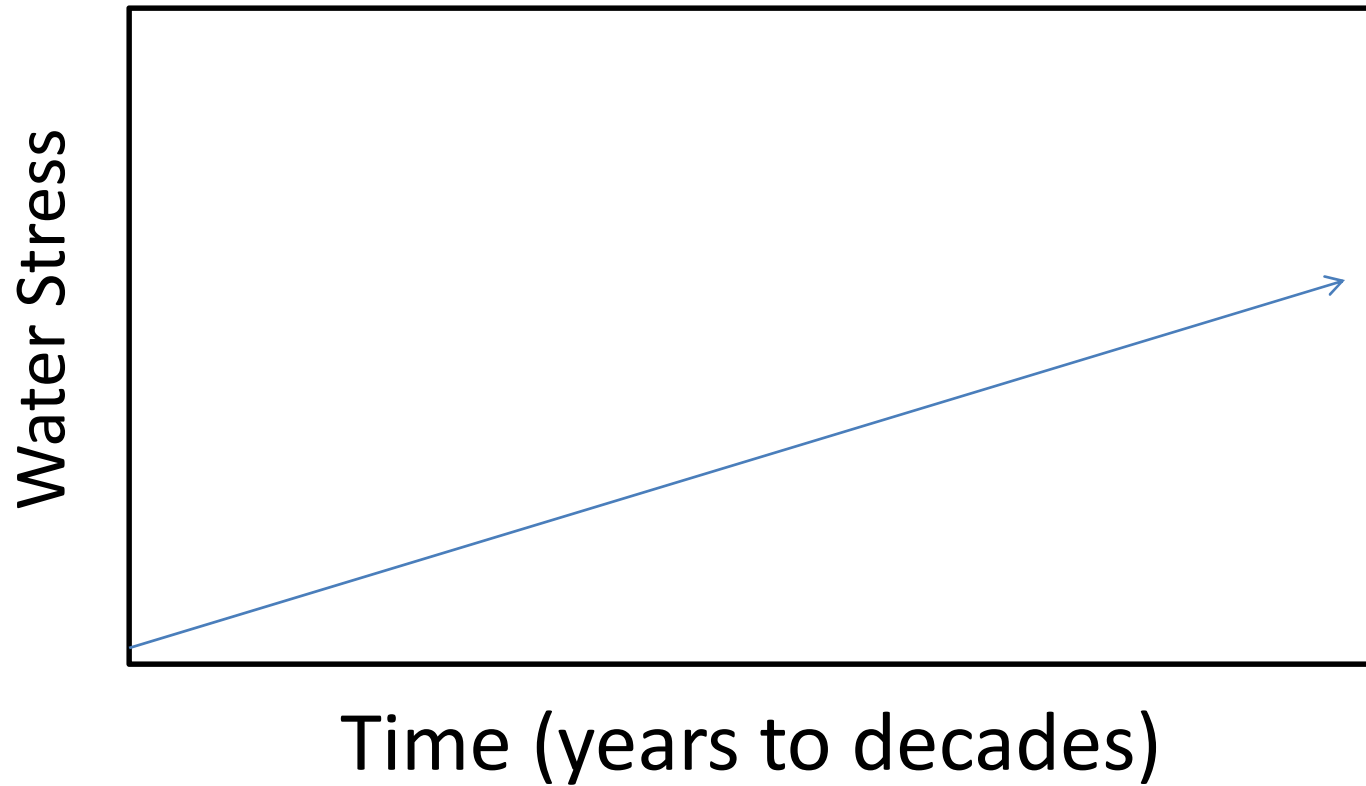
Extreme Drought can outweigh positive feedbacks



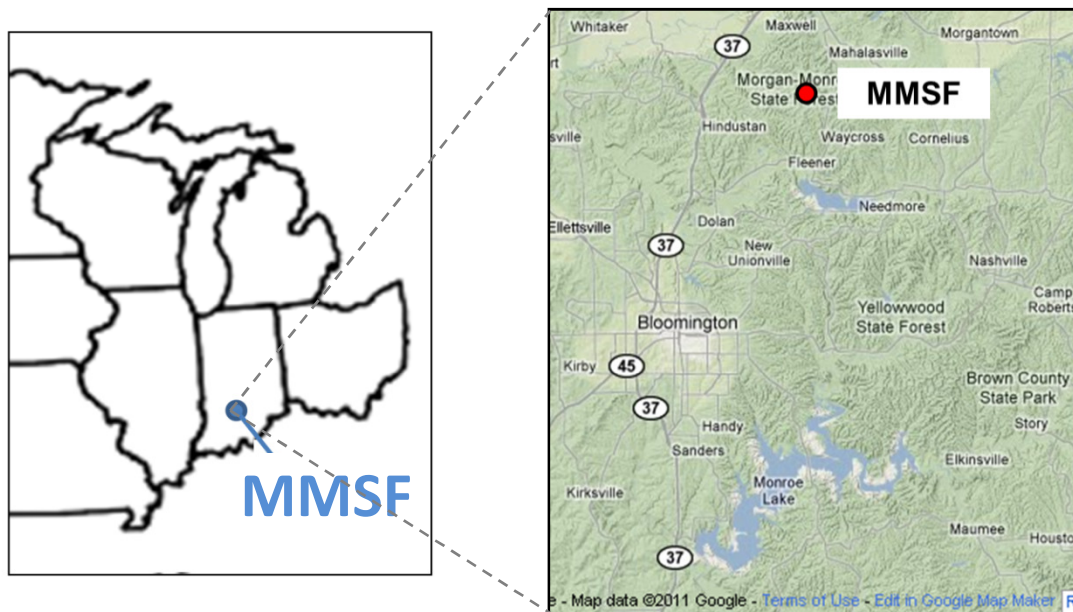
Ciais et al. (2005)



Impacts of chronic water stress on C storage?



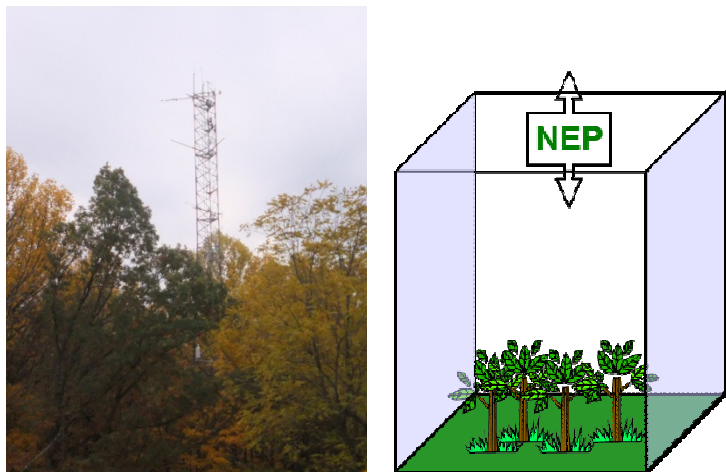
What are the carbon consequences of chronic water stress for Eastern deciduous forests?



MMSF is a deciduous broadleaf forest located in the central hardwoods region in southern, IN.

Diverse Mixture of trees:
Sugar Maple
White, Red, Black Oak
Hickories
Beech
Tulip Poplar
Sassafras

Since 1998, eddy-covariance measurements of Net Ecosystem Productivity (NEP) have been coupled with biometric measurements on the ground.

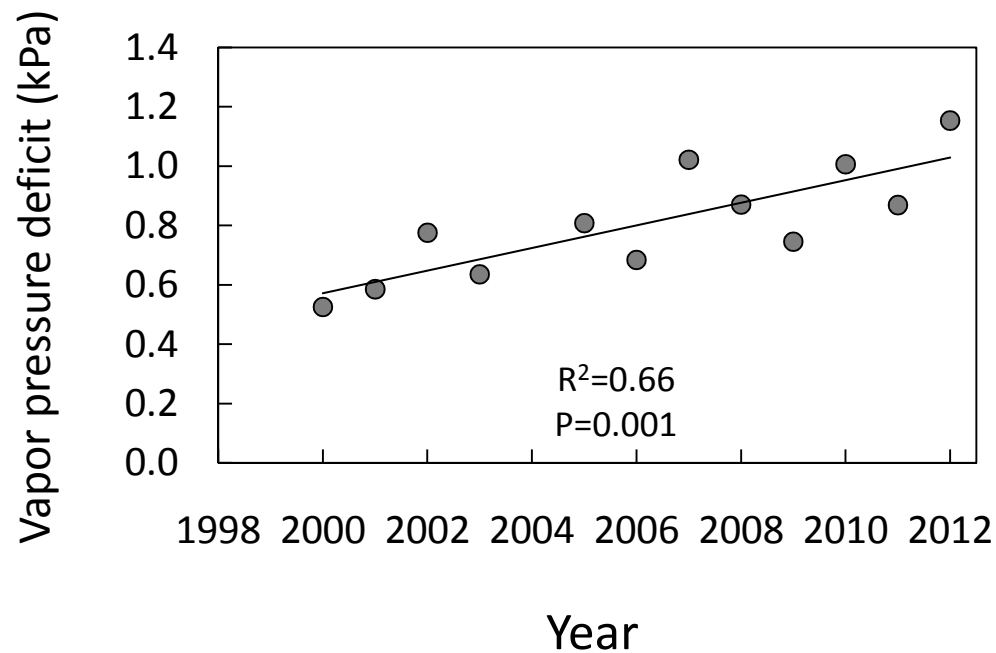
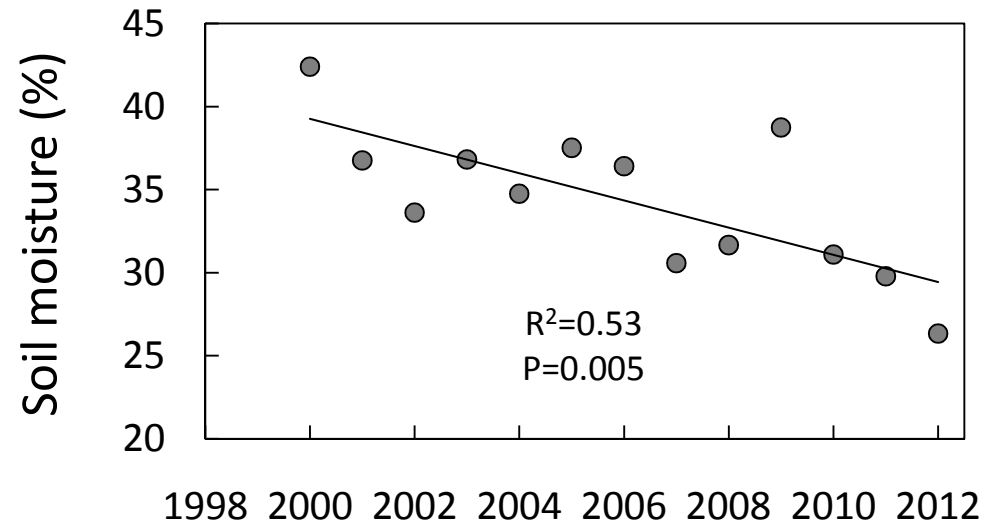


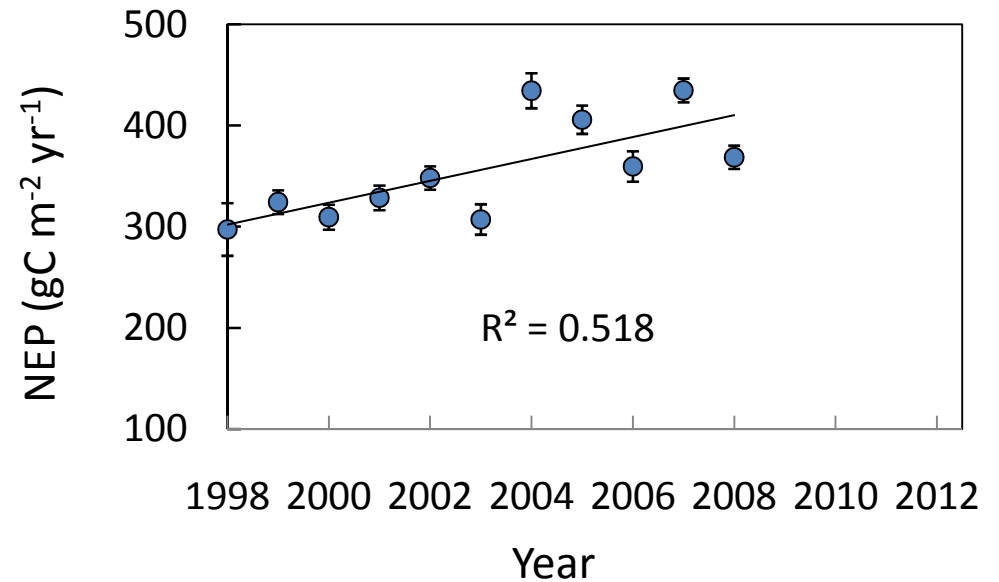
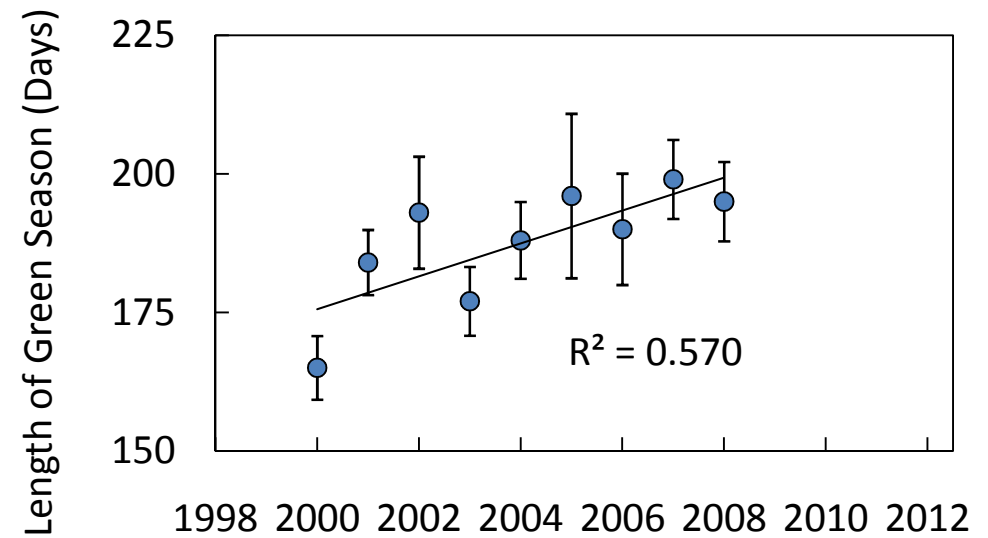
46m tower
instrumented with eddy-
covariance station.



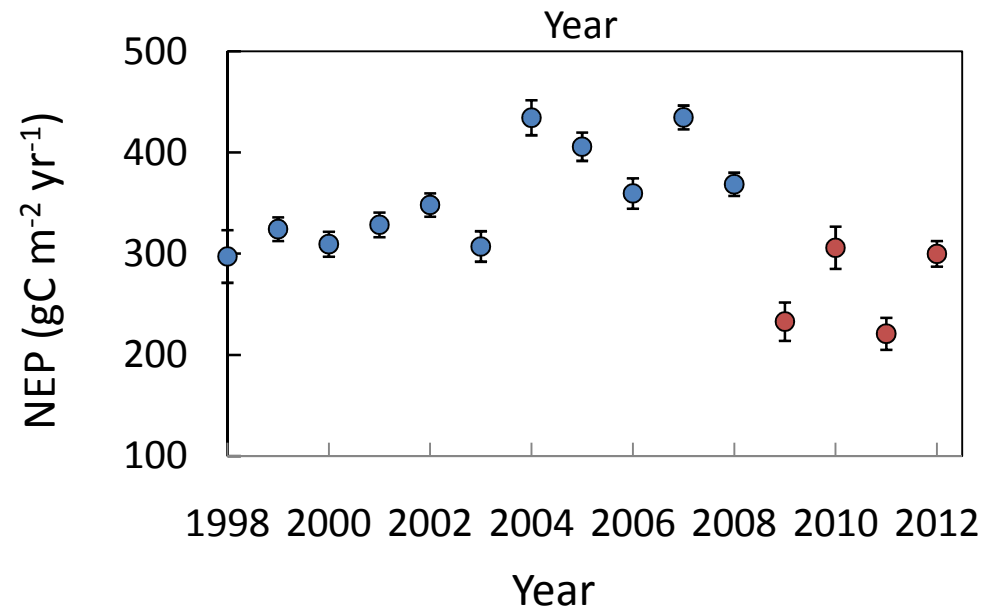
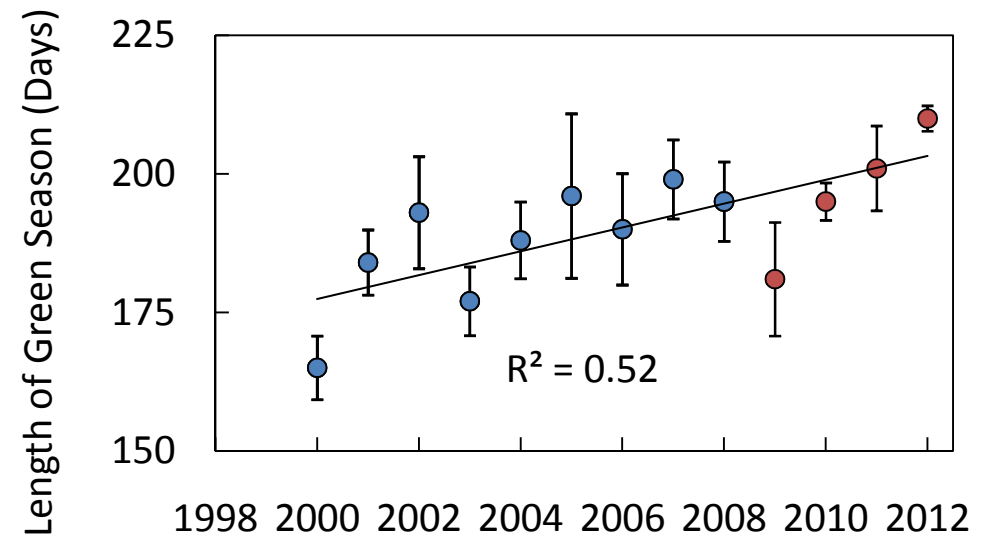
34 Biometric Plots located in
tower footprint with over 200
trees instrumented with
dendrometer bands.

The forest has been getting progressively drier during the growing season.





Figures modified from Dragoni et al. 2011



Figures modified from Dragoni et al. 2011

What are the effects of canopy phenology on wood phenology and production?

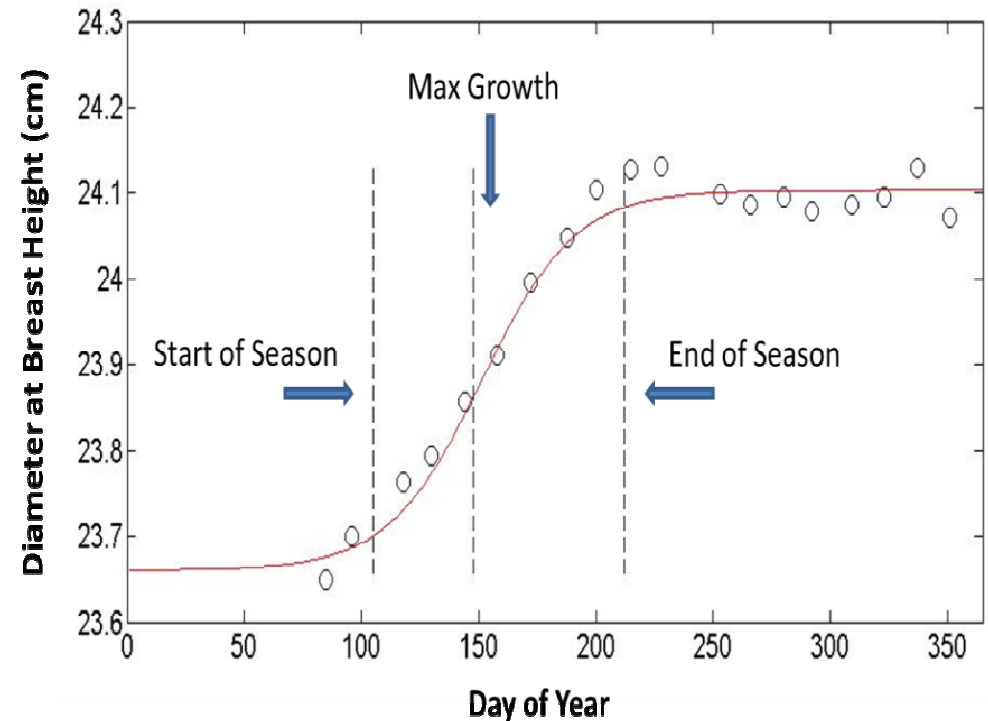


&

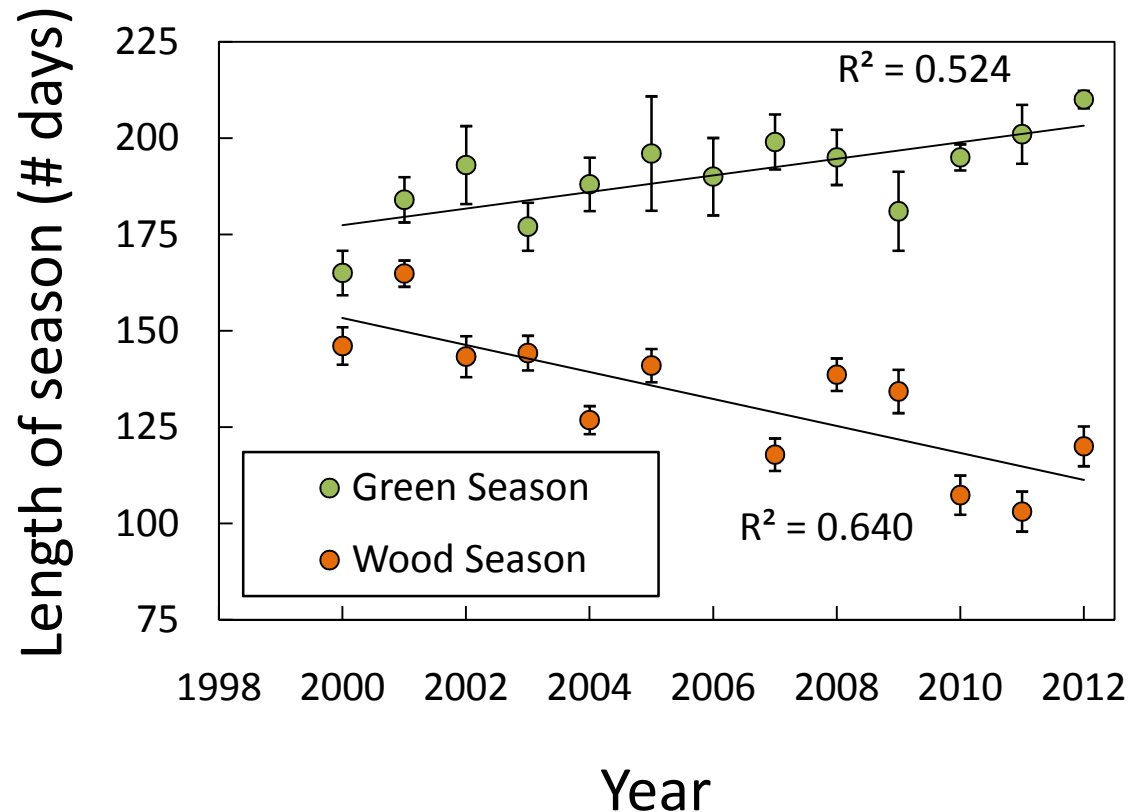


C stored in
wood

Using bi-weekly measurements of dbh increments we were able to estimate wood production phenology.



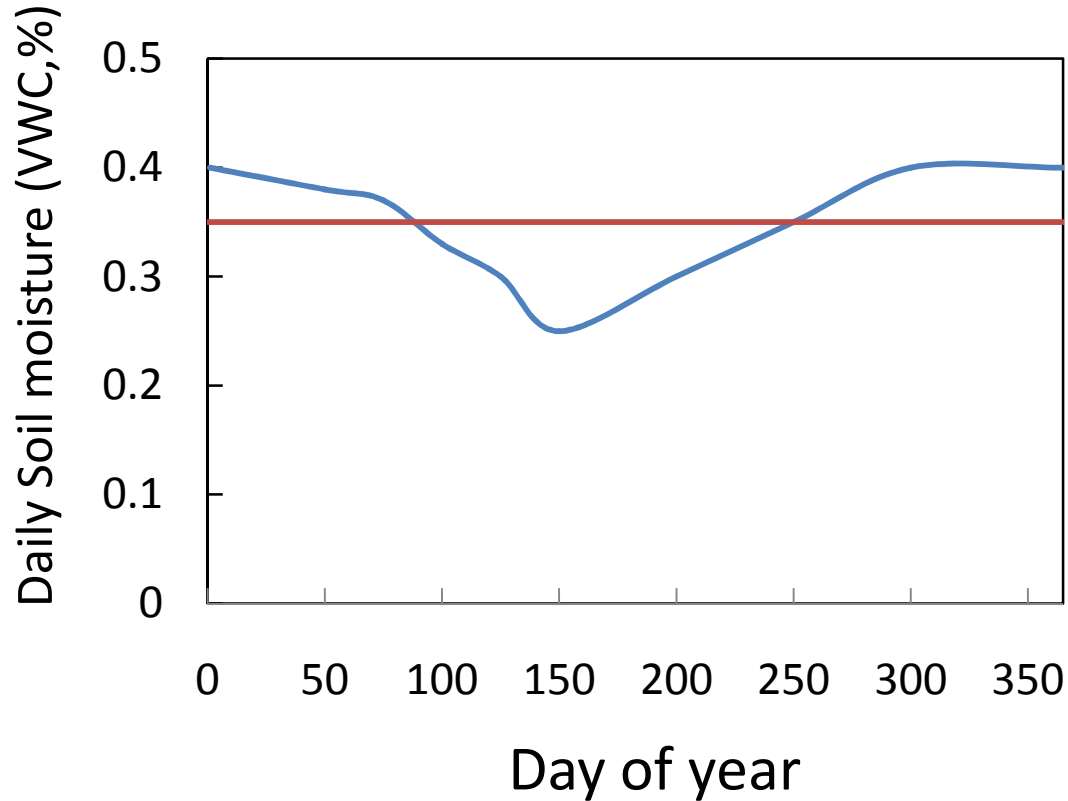
Canopy and wood phenology has diverged:



Green season length has increased by ~26 days; whereas the wood season has decreased by ~42 days

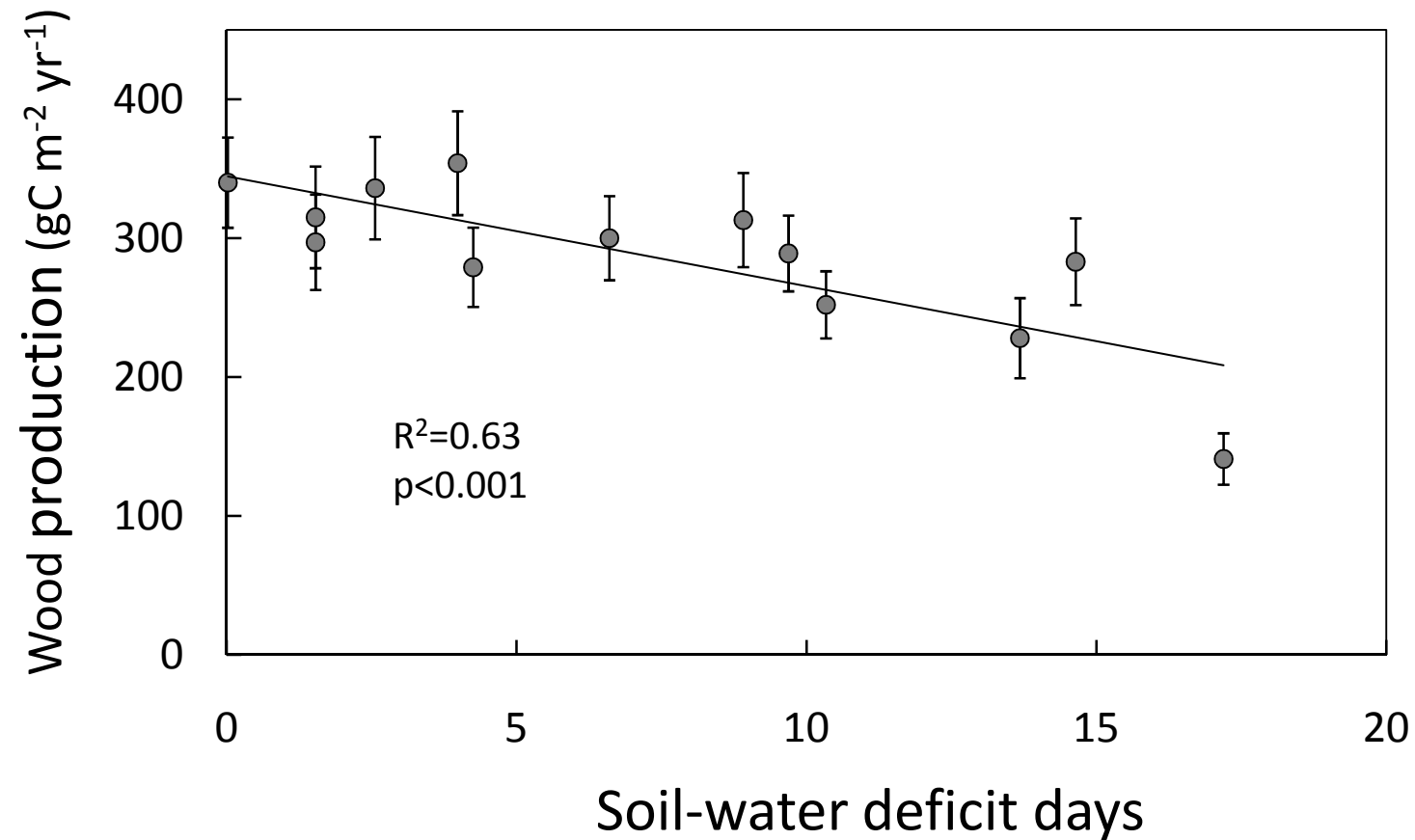
Using multiple linear regression, soil moisture was the lone factor explaining changes in both phenologies.

Soil-water deficit days

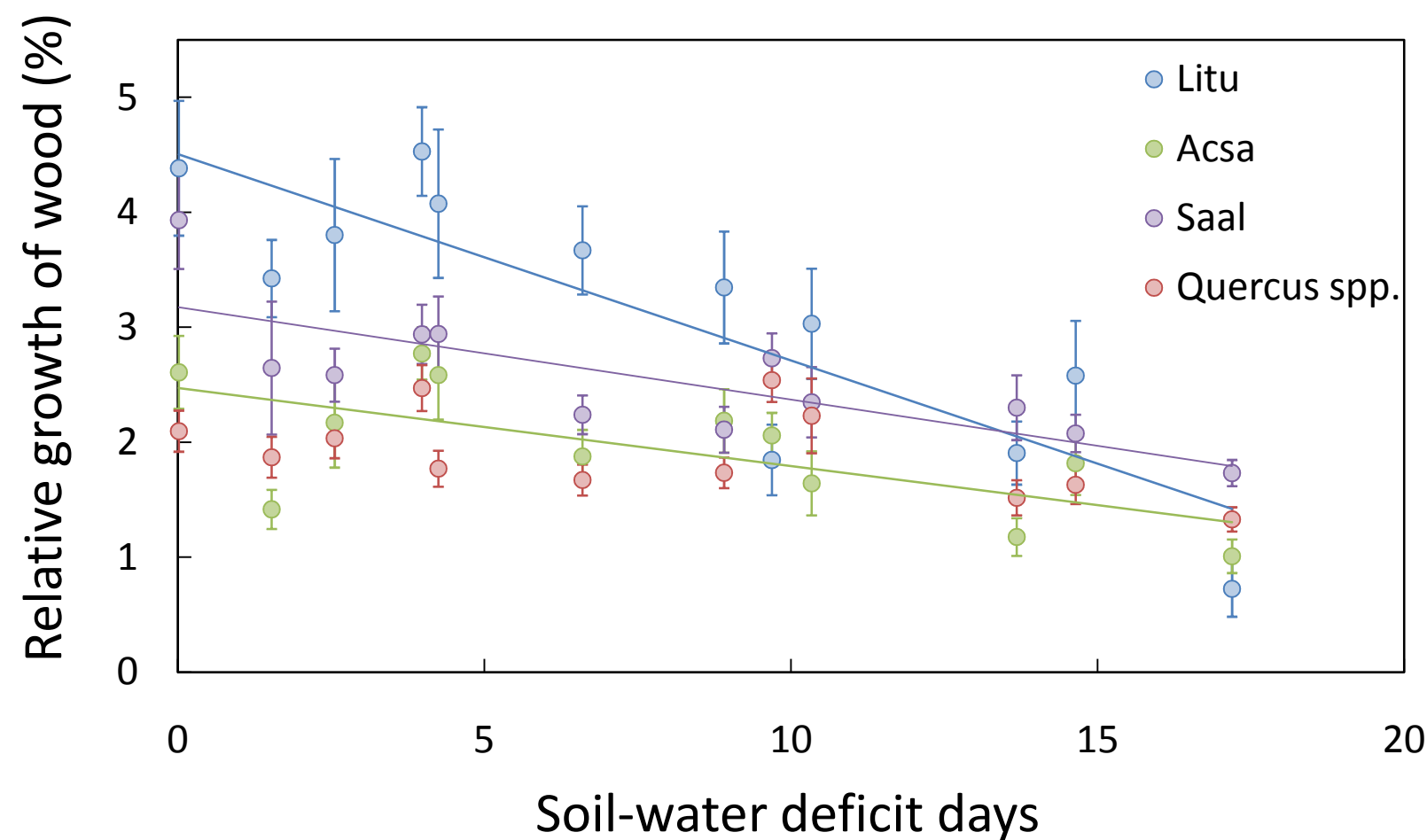


Integrate the difference between the long-term mean soil moisture and values that fell below this mean threshold over the growing season

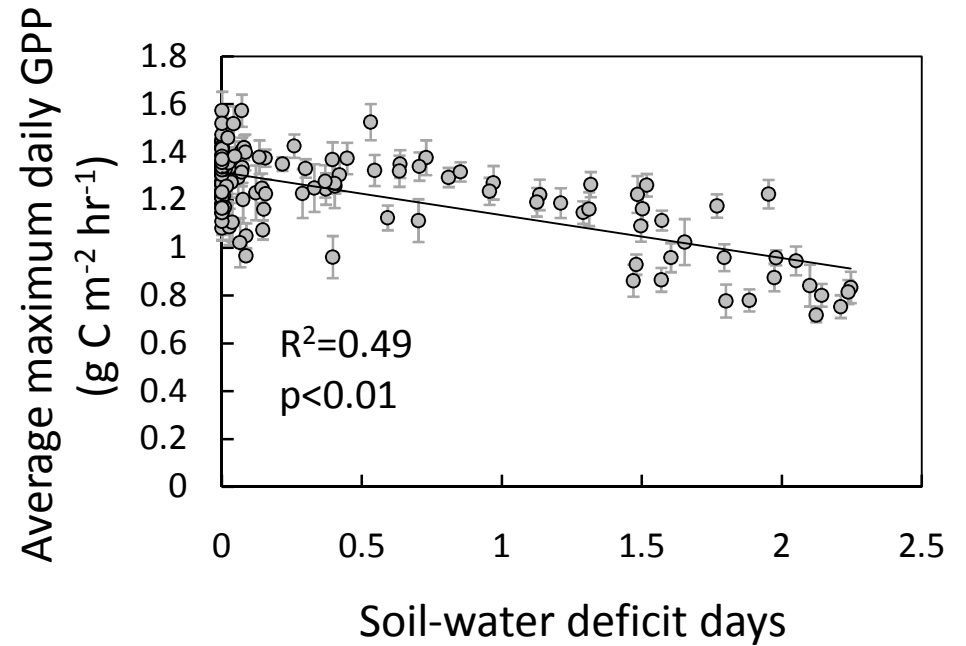
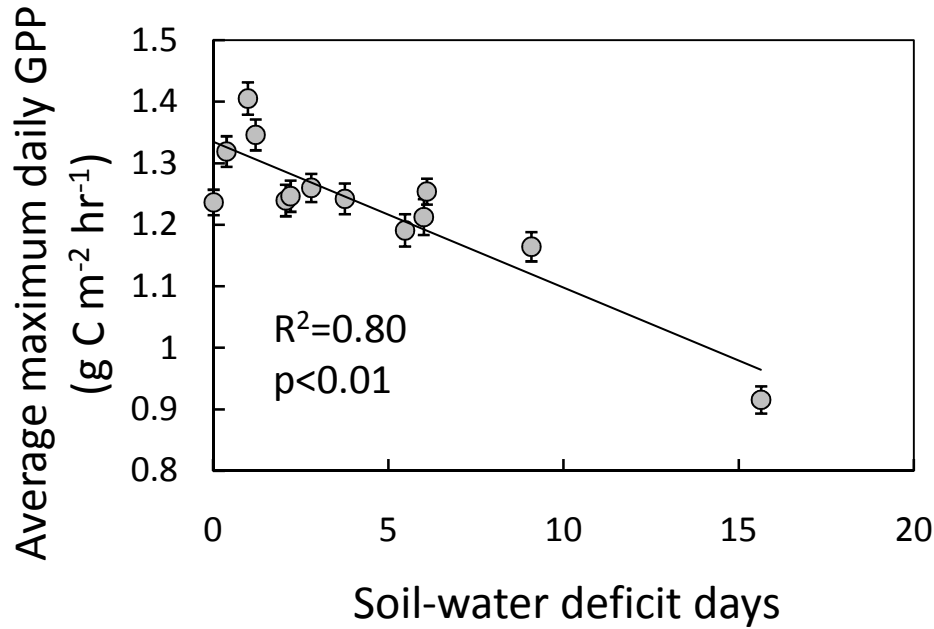
Increases in water stress have led to less C stored in wood



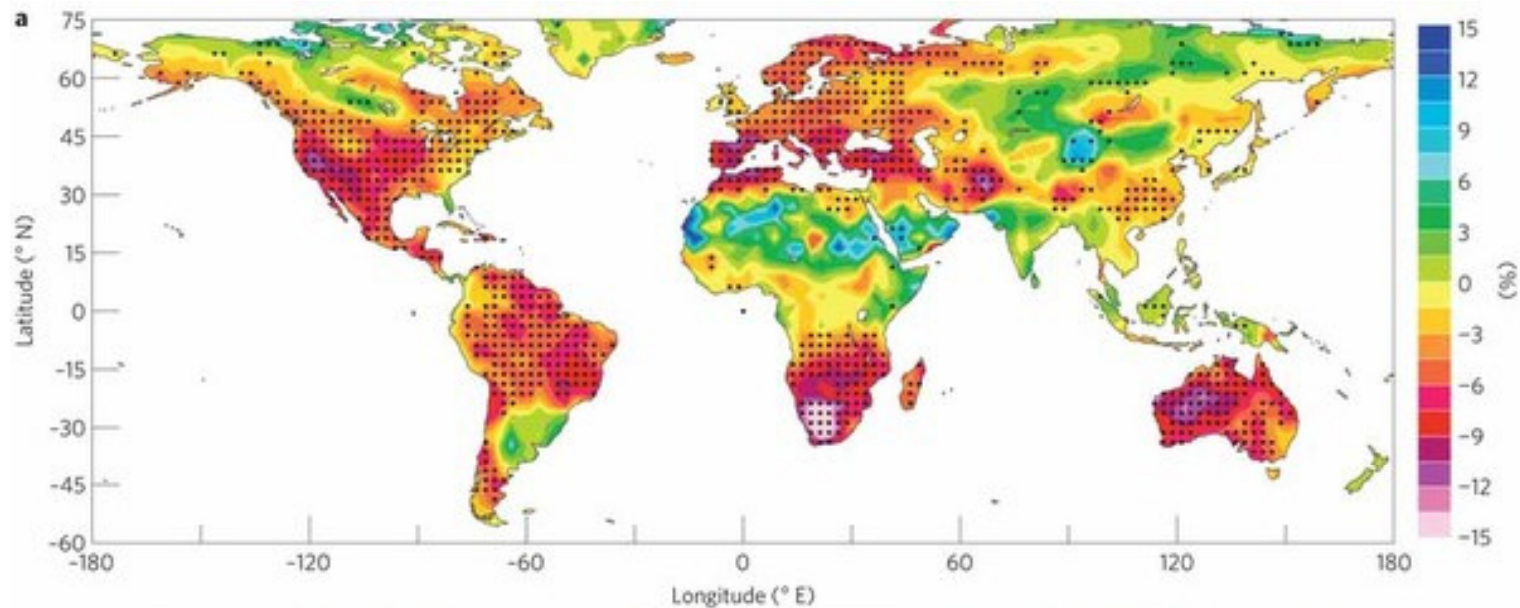
The overall forest wood production response was primarily driven by the declines of water-sensitive tree species



A portion of the wood production decline may be driven by less C assimilation with chronic water stress.

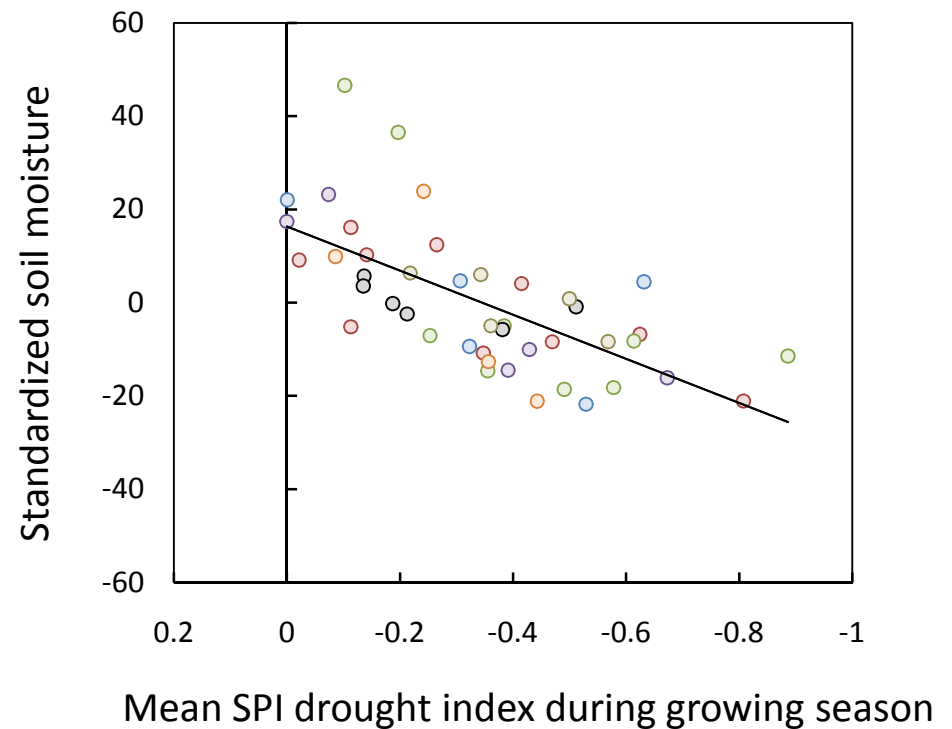
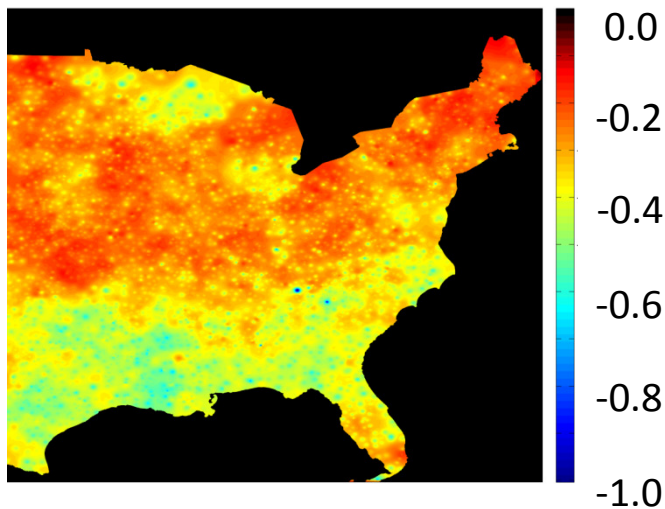


What are the potential C consequences for the region as a whole?

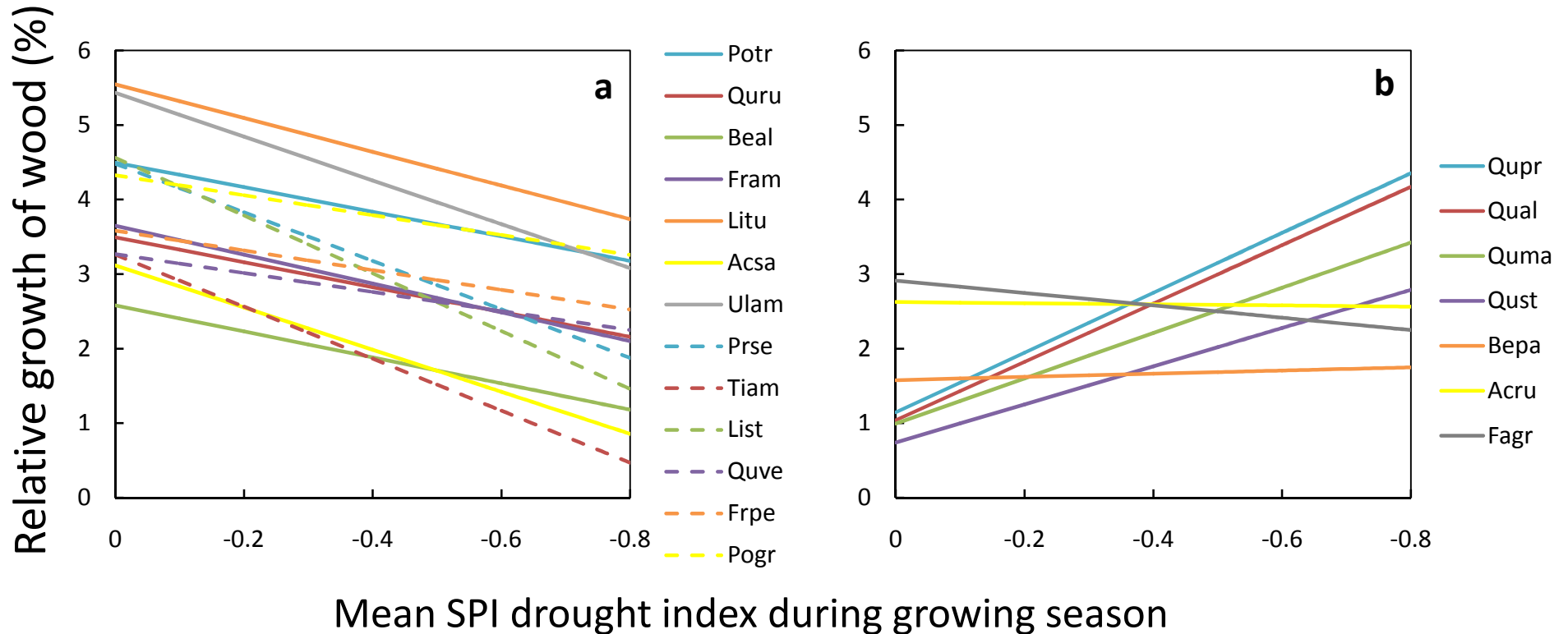


The vast majority of the region is predicted to get drier (Dai, 2012).

We linked growth data from FIA for the twenty most dominant tree species with the Standardized Precipitation Index.



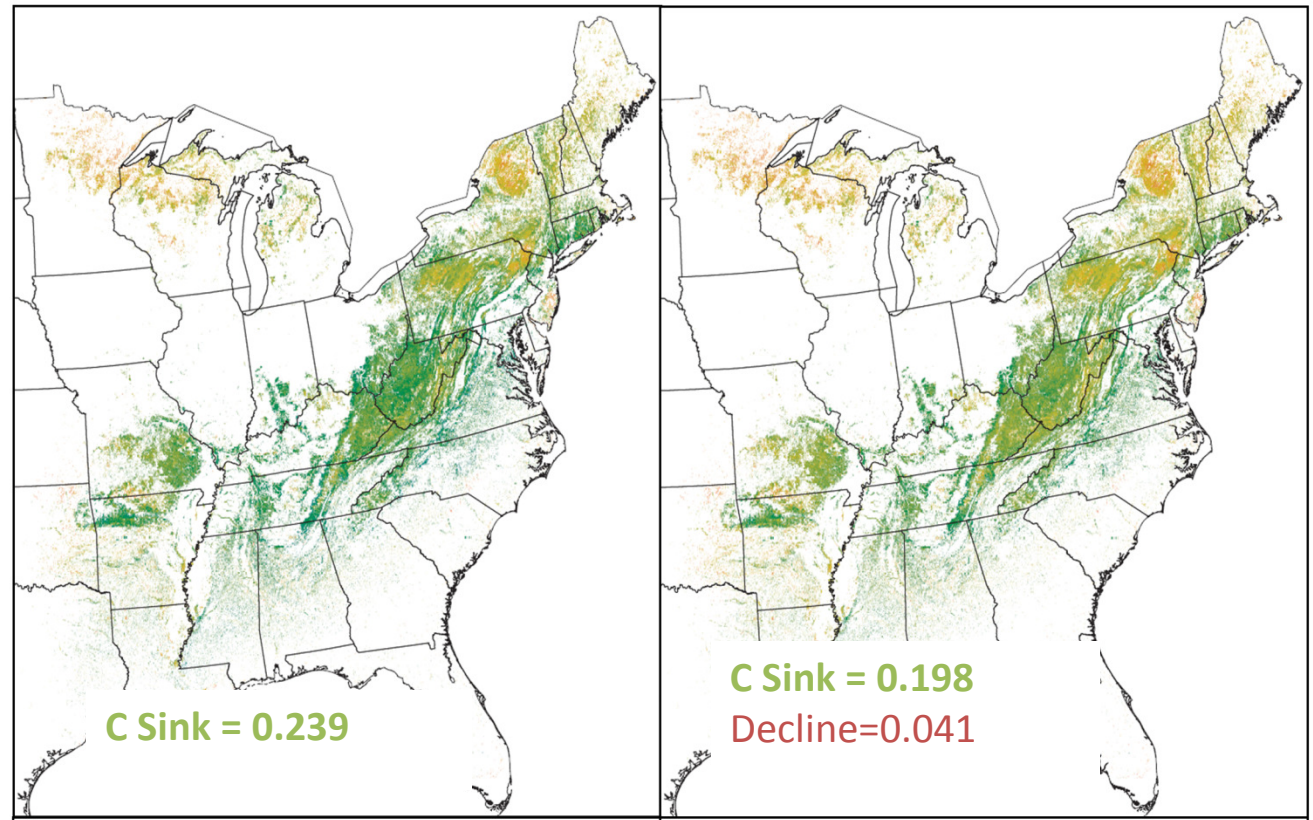
The majority of tree species across the Eastern and Midwestern US show strong sensitivity to water stress.



Regional Estimate:

- (1) Wood production is around 85% of NEP at MMSF
- (2) Eastern deciduous broadleaf forest account for $0.24 \text{ Pg C m}^{-2} \text{ yr}^{-1}$
- (3) Applying a 20% decline in water availability (representing half the overall decline and range in chronic water stress)

17% Decline in
regional C sink



Summary

- Chronic water stress has caused shifts in phenology and reductions in the strength of the C sink at MMSF despite longer growing seasons and increased WUE.
- Increasing water stress is not only influencing physiology (GPP declines) but altering wood production – a C pool which dominates long-term C storage.
- Predicted increases in water stress have the potential to cause substantial declines in the C sink of the Eastern deciduous forests.



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